Title: 2019 Delta Juvenile Fish Monitoring Program- Salmonid Annual Report

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Introduction

Out-migrating juvenile Chinook Salmon (*Oncorynchus tshawytscha*) and Steelhead (*O. mykiss*) of the Central Valley, California, must travel from their upstream natal tributaries into the Sacramento-San Joaquin Delta (Delta) prior to reaching the Pacific Ocean to rear in the marine environment. The Central Valley Project (CVP) and State Water Project (SWP), water operation projects that supply water to over 27 million Californians, have the potential to affect these salmonids and their rearing habitats throughout the Delta (Kimmerer 2008; NMFS 2009,2019). The effects of these water operations, in part, depends on the timing and distribution of salmonids throughout the system, which can be highly variable from year to year due to a variety of environmental factors (Munsch et al. 2019). Since 1976, the U.S. Fish and Wildlife Service's Delta Juvenile Fish Monitoring Program (DJFMP) has monitored the annual timing, distribution, and relative abundance of juvenile salmonids throughout the Delta to better our understanding, inform the management, and mitigate the impacts of the CVP and SWP water export operations on their populations.

The purpose of this report is to provide a brief communication on the distribution of juvenile salmonids observed during the DJFMP 2019 field year (August 2018 to July 2019) in terms of their: 1) immigration into the Delta; 2) residency within the Delta; and 3) emigration from the Delta.). Information on our non-salmonid catch trends can be found in the DFJMP Nearshore Fishes Annual Report. The complete DJFMP dataset—including environmental data not included in this report—and a complete description of sampling procedures is available at DJFMP's Environmental Data Initiative Data Portal (IEP et al. 2020).

Methods

Sampling Locations

Over the years, the DJFMP has used a variety of gear types deployed at different time periods and frequencies throughout the year to examine the temporal and spatial distribution of fishes throughout the littoral and in-channel habitats of the Delta and greater San Francisco Estuary (Figure 1). A complete description of the historical and current methods is available at the DJFMP Environmental Data Initiative Data Portal (IEP et al. 2020). In this report, we use relative site names in place of our traditional beach seine region numbers and trawl site names to aid in the spatial orientation of readers, thus: Seine Region 1 = Lower Sacramento; Seine Region 2 = North Delta; Seine Region 3 = Central Delta; Seine Region 4 = South Delta; Seine Region 5 = Delta Entrance Seine (San Joaquin River Basin); Region 6 = Bay Seine; Seine Region 7 = Delta Entrance Seine (Sacramento River Basin); Sherwood Harbor Trawl = Delta Entrance Trawl (Sacramento River Basin); Mossdale Trawl = Delta

Entrance Trawl (San Joaquin River Basin); Chipps Island Trawl = Delta Exit.

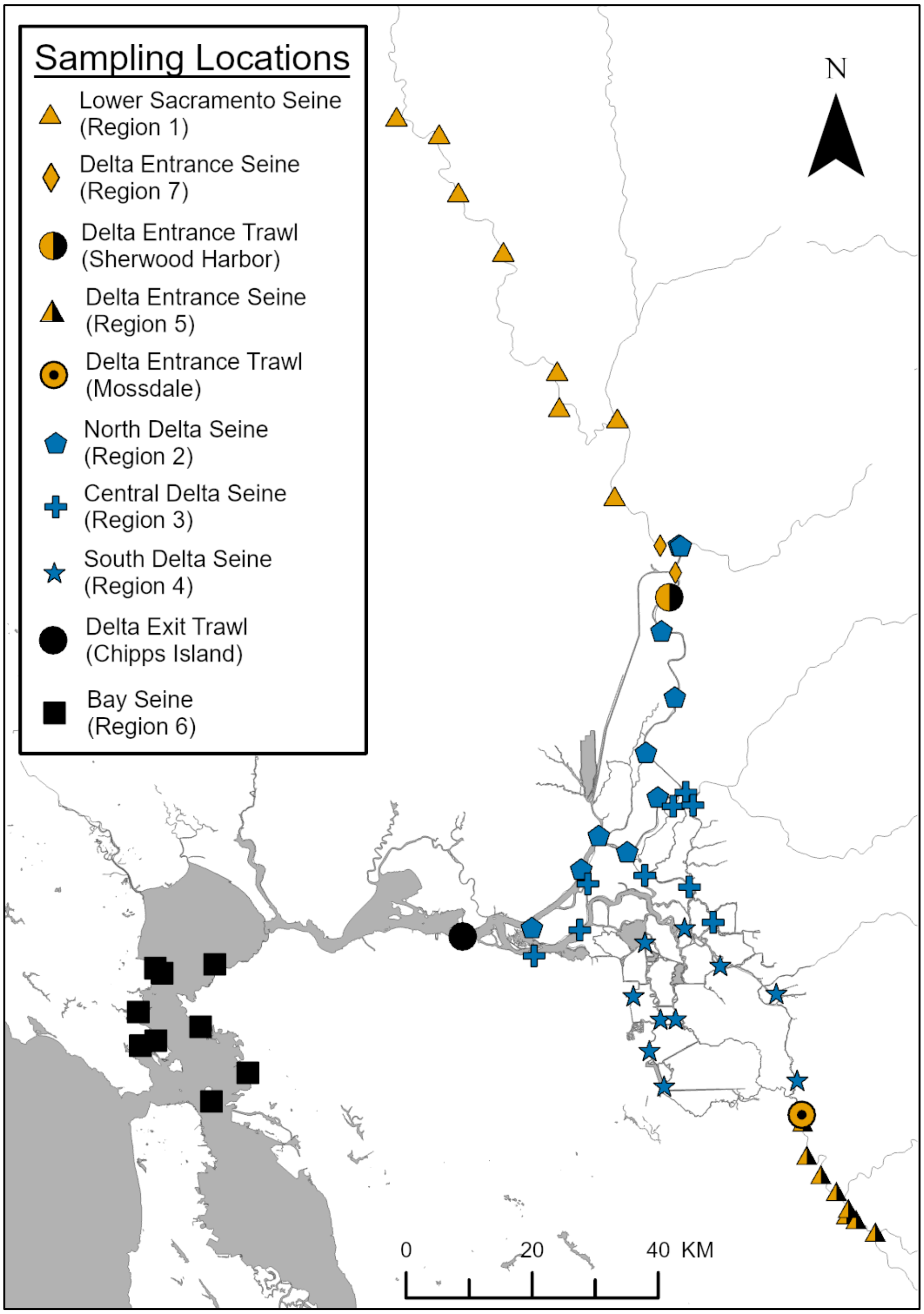

Figure 1. Long-term sampling sites for the USFWS Delta Juvenile Fish Monitoring Program.

Sampling Methods

During the 2019 field year the DJFMP used a combination of beach seines (hereafter referred to as “seine”) and surface trawling (mid-water and Kodiak trawls) to monitor the distribution of juvenile salmonids (Figure 1). Monitoring was conducted year-round during daylight hours (between 6:00 am and 6:00 pm), except for the Delta entrance seine (Sacramento River Basin; discussed below). Typically, ten 20-min trawls were conducted a minimum of three days per week at each trawling site and all seine sites were sampled once per week, except for: 1) Bay Seines, which were sampled every other week throughout the year, and 2) Delta entrance seines (Sacramento River Basin) and a few

North Delta seines, which were sampled three times per week from October 1 through the last week of January, to intensely monitor juvenile winter-run Chinook Salmon entering into the Delta from the Sacramento River Basin. The California Department of Fish and Wildlife (CDFW) sampled the Delta entrance trawl site (San Joaquin River Basin) in place of DJFMP between the months of April and June following similar methods. Data collected from both DJFMP and CDFW efforts are included in this report.

Fish Processing

Captured fishes ≥ 25 mm fork length (FL) were measured to the nearest 1 mm FL (except for a few species that can be easily identified at < 25 mm fork length). The race of all unmarked juvenile Chinook Salmon were determined using the river Length at Date Criteria (LDC) developed by Fisher (1992) and modified by Greene (1992), except for individuals captured at the Delta entrance trawl site (San Joaquin River Basin); and Lower San Joaquin River Seine Region. These individuals were classified as non-winter-run regardless of LDC since winter-run Chinook Salmon are not known to occur within the San Joaquin River and its main tributaries (Yoshiyama et al. 1998). If more than 50 individuals of a Chinook Salmon race were captured, a subsample of 50 individuals were randomly selected and measured. The rest of the captured fish were counted, but not measured. All juvenile salmonids with missing (i.e., clipped) adipose fins, pelvic fin clips (used to mark a specific brood stock of winter-run hatchery fish in some years), and other forms of marks or tags (e.g., stain dye, disc tags, acoustic tags) were recorded as marked along with their respective marking type. All juvenile Chinook Salmon with missing adipose fins observed and intact pelvic fins were considered hatchery-reared and were brought back to the lab for coded wire tag extraction, race determination and origin via the Regional Mark Information System database (RMIS 2021). Juvenile Chinook Salmon with missing adipose fins and pelvic fin clips were recorded as hatchery-reared winter-run and were released. Juvenile Steelhead with missing adipose fins were recorded as hatchery-reared and were released. Water quality variables (i.e., water temperature, dissolved oxygen, turbidity, and conductivity) were measured immediately before each trawl and during or after each seine haul but are not included in this report.

Data Analysis

Before estimating catch-per-unit-effort (CPUE), we filtered the dataset by excluding samples collected during poor sampling conditions, such as twists in the net or major cod-end blockages (i.e., gear condition code > 2 in the DJFMP dataset), when debris was present on flow meters, and outliers in sampling volumes. For seines, volume outliers were identified by the exceedance of the standard minimum and maximum seine net dimensions set by the DJFMP standard operating procedures for seines. For trawls, volume outliers were identified as values that were more than 1.5 times the interquartile range above the third quartile or below the first quartile of pooled volumes by trawl site using the boxplot.stats function in R (R Core Team 2021). Our outlier checks resulted in 3,261 out of 96,193 trawl (3.3 %) and 24 out of 41,157 (< 1%) seine samples being removed from our final dataset. The high number of outliers in the trawl dataset were likely due to transcription errors and intermittent debris on flow meters during sampling. All juvenile salmonids with missing (clipped) adipose fins were treated as marked hatchery fish in our dataset. Salmonids used in directed studies that possessed other forms of marks or tags (e.g., stain dye, disc tags, acoustic tags), were not considered part of regular hatchery releases and were excluded from our catch dataset to avoid biasing our calculations of the proportion of hatchery and wild origin fish in samples. Since 1998, all juvenile winter-run Chinook and Steelhead produced from California hatcheries have been adipose fin clipped; therefore, all unmarked individuals were classified as wild origin (USFWS 2011, NMFS 2014). For non-winter-run Chinook Salmon, we estimated the number of unmarked hatchery fish in samples collected after the 2008 implementation of the Central Valley Constant Fractional Marking Program using the methods detailed in Graham et al. (2018). Before 2008, non-winter run Chinook Salmon were classified as unknown origin fish.

To compare the relative abundance of juvenile salmonids across space and time we calculated mean monthly and annual volumetric catch-per-unit-effort (CPUE) values for each seine region and trawl site. The mean monthly and annual CPUE values were calculated with a series of averages of averages to avoid overweighting sampling locations due to differences in sampling frequency. First, we calculated a sample CPUE value for each specific fish type (hatchery origin winter-run Chinook, wild origin winter-run Chinook, hatchery origin Steelhead, wild origin Steelhead, etc.) by dividing the total number of individuals caught by the total volume of water sampled, for each sample (fish/ 10,000 m^3). We then averaged sample CPUE values by month within sampling locations, and then averaged the mean monthly CPUE values for sampling locations across their respective seine region or trawling site within each month, to obtain the mean monthly CPUE for each seine region and trawl site reported here. We calculated mean annual CPUE values for each seine region and trawl site by averaging monthly CPUE values for each seine region and trawl site across months, within each field year.

Results and Discussion

Delta Immigration- Sacramento River Basin

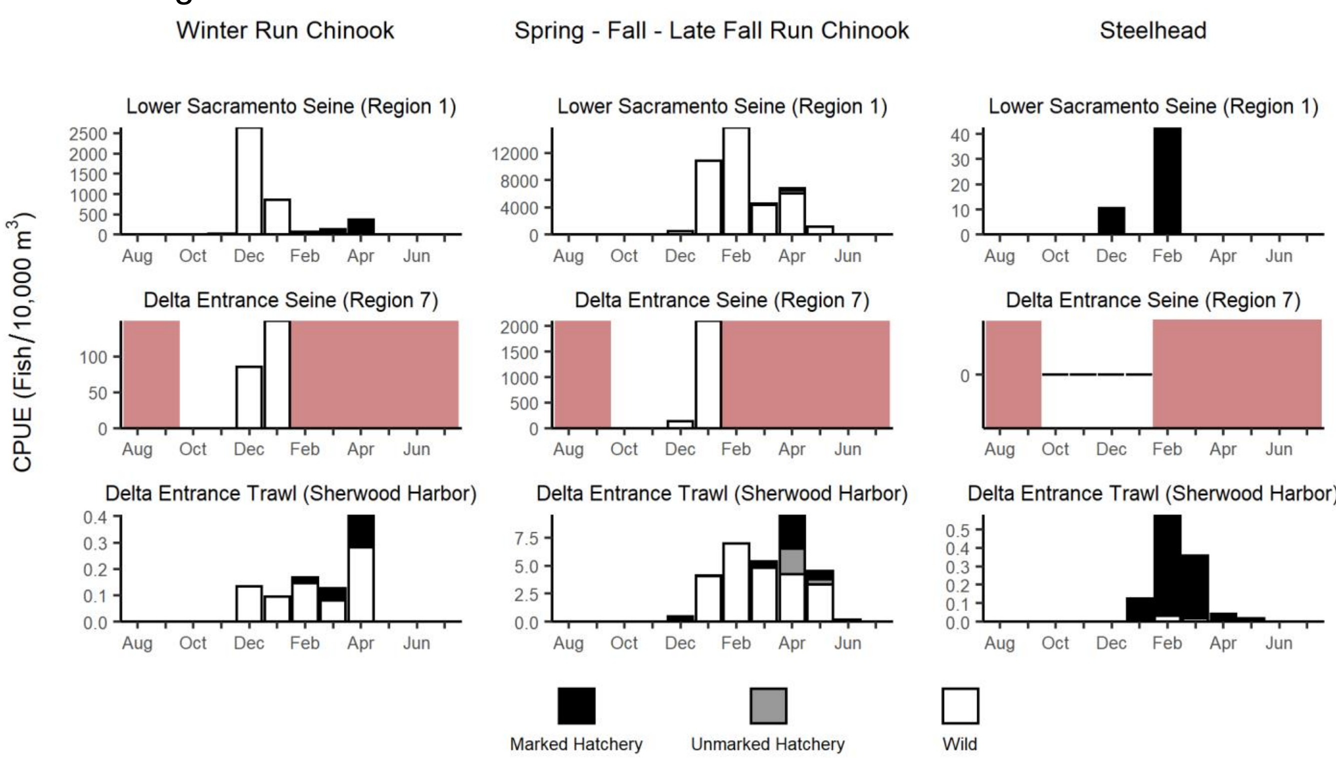

Figure 2. Timing of juvenile salmonids entering the Delta from the Sacramento River basin during the 2019 field year (August 2018 to July 2019). Seine and trawl sampling locations are located upstream of the Delta Cross Channel water diversion. The Sacramento River basin delta entrance seine was

conducted from October 1, 2018 to January 31, 2019 (shading indicates periods of no sampling). Note that y-axis scales vary by species and sampling location.

In the 2019 field year, we detected winter-run sized juvenile Chinook Salmon entering the Delta from the Sacramento River Basin from November 29 to April 10. Their relative abundance as detected by the Lower Sacramento River and Delta entrance seines peaked in the months of December and January while the Delta entrance trawl relative abundance peaked in April (Figure 2). Winter-run hatchery releases occurred in the months of February and March (RMIS 2021) and were detected at the Delta entrance from February through April. We observed a higher proportion of hatchery fish caught in trawls compared to seines. This trend has been observed across multiple years in this region and is likely the result of body size and habitat use differences between hatchery origin and wild-stock fish. Specifically, salmonids in near-shore habitats sampled by seines are found to be smaller (wild origin), while larger, hatchery origin fish tend to reside in deep channel habitats sampled by trawls (Roegner et al. 2016).

Spring-, late fall-, and fall-run sized juvenile Chinook Salmon were detected from November 30 to July 24 during the 2019 field year. At seine sites, peak relative abundance was observed in January and February and trawl relative abundance peaked in April (Figure 2). The proportion of hatchery fish in trawl catches coincided with the timing and magnitude of hatchery releases, which occurred from the months of December through May (RMIS 2021).

Juvenile Steelhead were detected from December 3 to May 28. Their relative abundance peaked in February for both the Lower Sacramento River seine sites and the Delta entrance trawl (Figure 2). Hatchery origin individuals made up 96.4% (165 of 171 individuals) of the juvenile Steelhead captured in this region. The six wild origin juvenile Steelhead were captured via mid-channel trawls as they entered the Delta from February to May. The scarcity of wild origin Steelhead in our catches from the Sacramento Basin highlight the relatively poor condition of wild Central Valley Steelhead populations within the region (NMFS 2016).

The full operation details of the Delta Cross Channel water diversion during the 2019 field year can be found in the annual reports of the Delta Operations for Salmonids and Sturgeon Technical Working Group (DOSS 2018; 2019). The overall timing and duration of DCC closures corresponded with our detection periods of juvenile salmonid in the region (Figures 2 and 3); suggesting that the DCC was closed during the period when a large number of juvenile salmonids were present, thereby reducing their risk of entrainment.

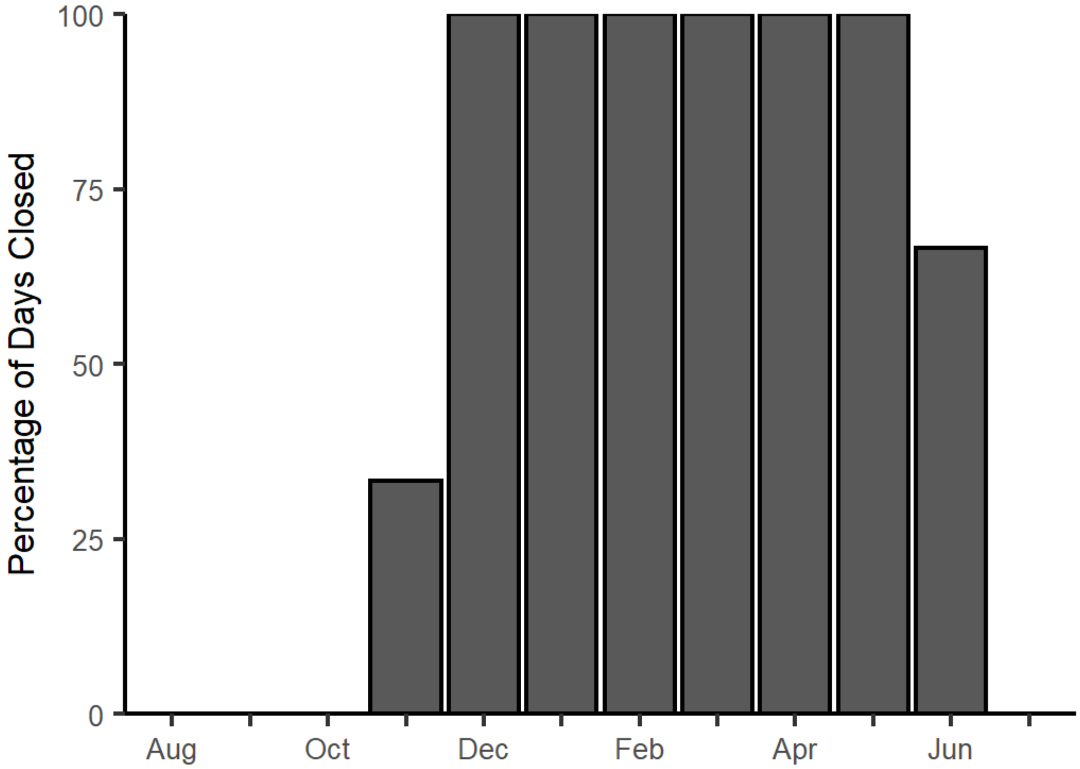

Figure 3. Summary of the Delta Cross Channel operations during the 2019 field year (August 2018 to July 2019).

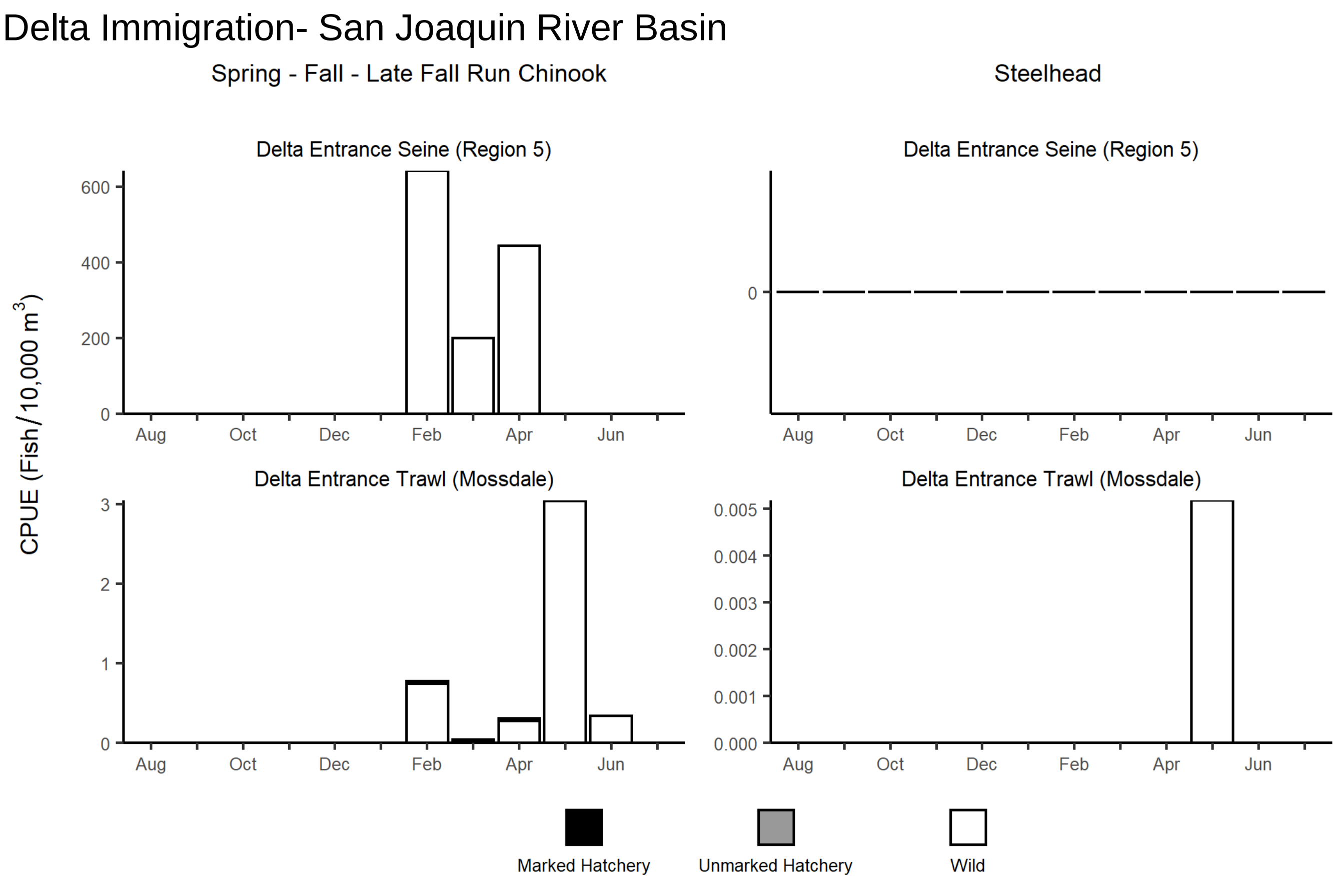

Figure 4. Timing of juvenile salmonid immigration to the Delta from the San Joaquin River basin during the 2019 field year (August 2018 to July 2019). Delta entrance seine and trawl sampling sites are located upstream of the head of Old River. Note that y-axis scales vary by species and sampling location.

At the San Joaquin River Delta entrance, we detected juvenile spring-, fall-, and late-fall sized juvenile Chinook Salmon entering the Delta from February 4 to June 26, with the peak relative abundance occurring in February (seines) and May (trawls) (Figure 4). Hatchery origin Chinook were detected exclusively by trawls from Feb 4 to May 24. The higher catch rate of hatchery Chinook in trawls is consistent with the trends seen at the Sacramento Delta entrance and juvenile hatchery Chinook behavior (Roegner et al. 2016). Hatchery spring-run Chinook originating from releases conducted by the San Joaquin River Restoration Program during the months of January and February were detected at the Delta entrance from February 4 to March 27.

Our Steelhead observations consisted of one wild-origin individual that was collected via trawl on May 6, 2019.

During the 2019 field year, installation of the spring fish barrier at the head of Old River was not attempted due to high flows on the San Joaquin River (DWR 2021). Therefore, a proportion of the juvenile salmonids entering the Delta from the San Joaquin River Basin likely used the Old River migratory corridor (Buchanan et al. 2013).

Delta Residency

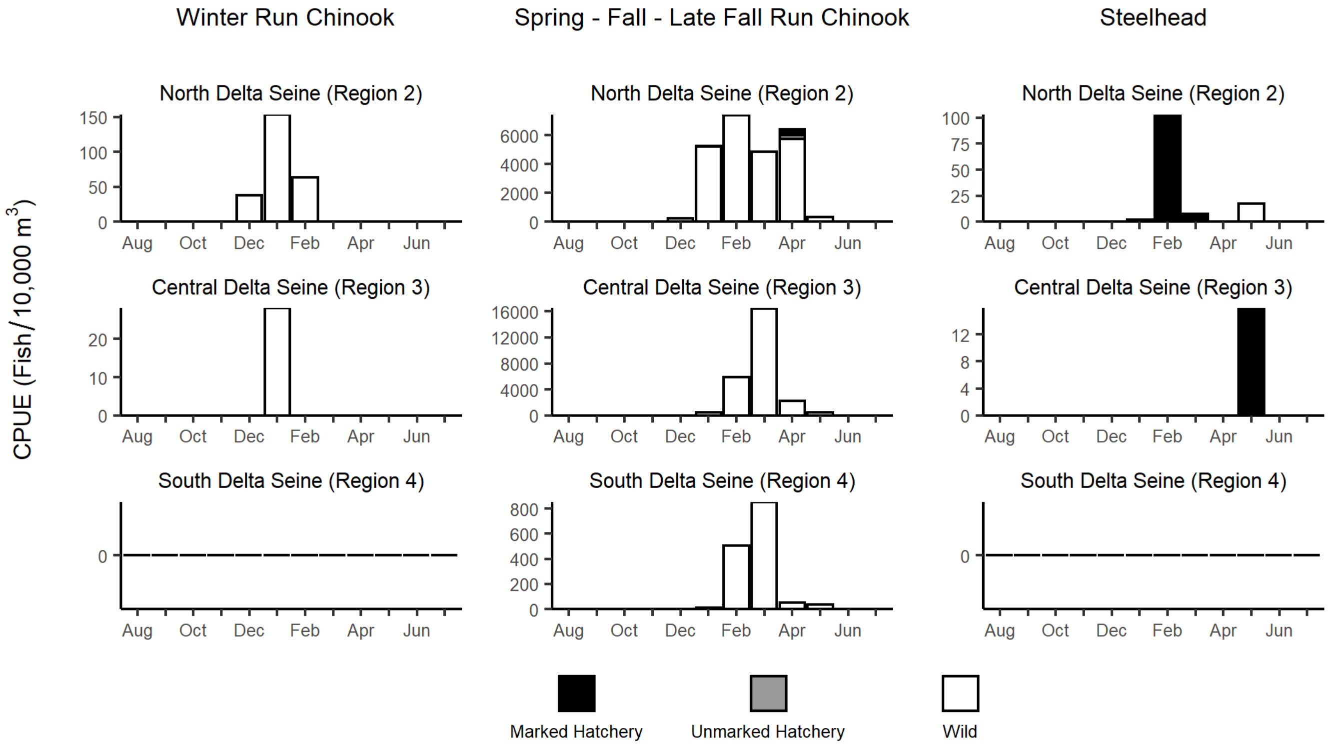

Figure 5. Timing of juvenile salmonid littoral habitat residency in the Delta during the 2019 field year (August 2018 to July 2019). Note that y-axis scales vary by species and sampling location.

We observed winter-run sized juvenile Chinook Salmon in the North Delta Region from December 4 to February 11, with a peak relative abundance occurring in the month of January (Figure 5). This was an increase in relative abundance compared to recent years and represented an 11-year high for the North Delta Region (Figure 6). We also observed winter-run sized juvenile Chinook Salmon in the Central Delta in January. Given the DCC was closed during this period, our catches suggest that some proportion of juvenile winter-run Chinook Salmon likely used the Georgiana Slough migration corridor and may have been subject to lower survival rates in the interior Delta (Newman 2008; Newman and Brandes 2010). No winter-run Chinook Salmon were observed in the South Delta Region.

Spring-, fall-, and late-fall sized juvenile Chinook Salmon were observed in the North Delta Region in the 2019 field year from December 4 to June 12, with a peak relative abundance occurring in the month of February (Figure 5). In the Central Delta, these juvenile Chinook Salmon were observed from January 16 to May 21 and relative abundance was at a 13-year high and surpassed the relative abundance we observed for the North Delta (Figure 6). We also observed fall- and spring-run sized juvenile Chinook in the South Delta Region from January 18 to May 16 and relative abundance was the highest recorded for the region for the past 20 years (Figure 6). The high relative abundance we observed in 2019 in the Central and South Delta was likely correlated to the high fall-run adult Chinook Salmon returns observed on the Mokelumne River in the Fall of 2018 (CDFW 2020).

We observed a total of 19 juvenile Steelhead in the North Delta Region in the 2019 field year from January 25 to May 29. Hatchery origin individuals made up 84.2% (16 of 19 individuals) of the catch. In the North Delta Region, relative abundance was higher in the 2019 field year for both hatchery and wild origin Steelhead compared to recent years (Figure 6). One hatchery origin Steelhead was also detected in the Central Delta Region during May. No Steelhead were observed in the South Delta Region.

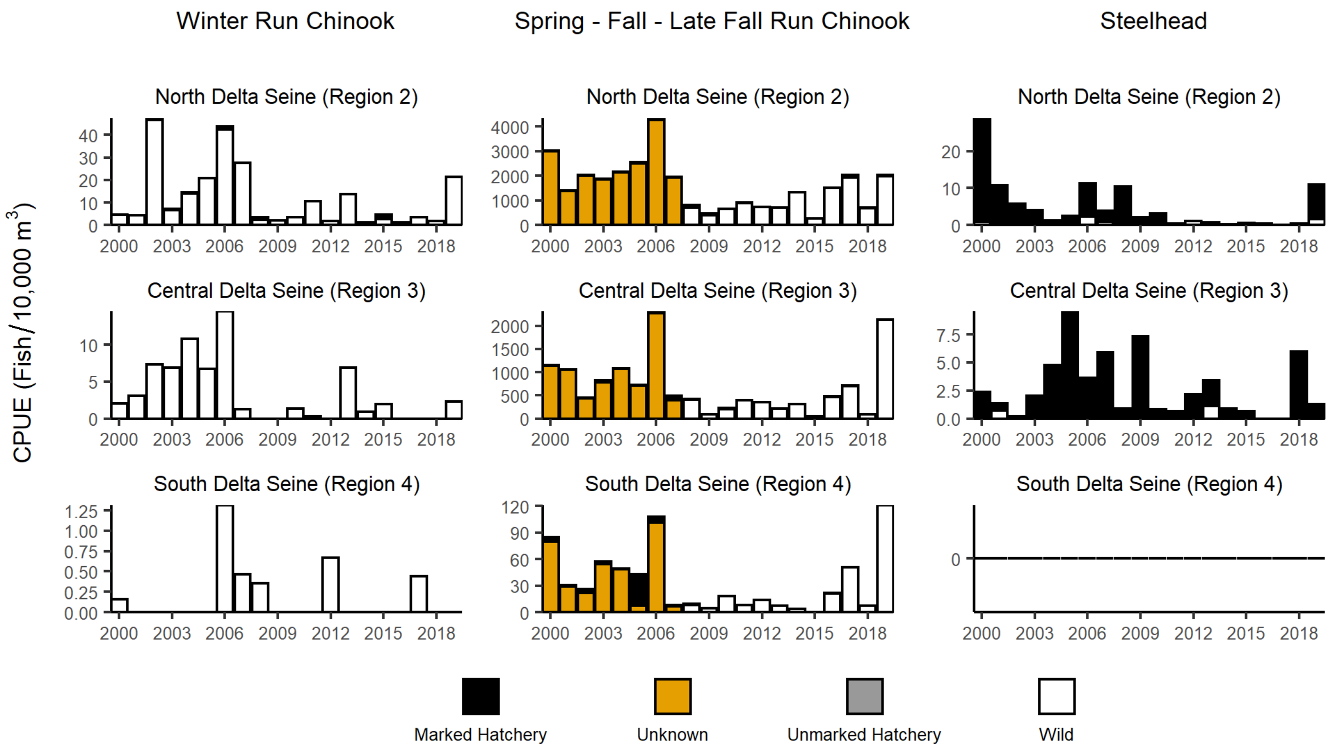

Figure 6. Annual relative abundance trends of juvenile salmonids in the Delta from 2000 to 2019. Note that y-axis scales vary by species and sampling location.

Delta Emigration

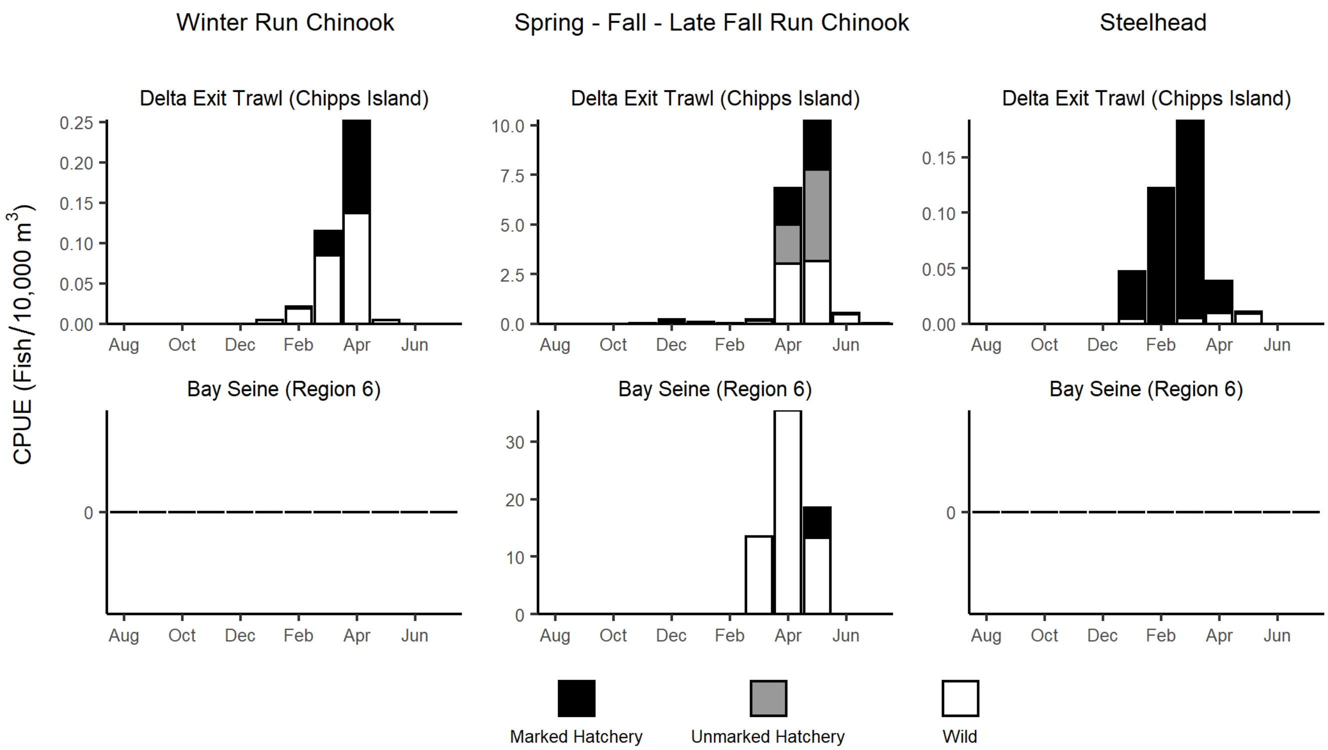

Figure 7. Timing of juvenile salmonid emigration from the Delta during the 2019 field year (August 2018 to July 2019). Note that y-axis scales vary by species and sampling location.

Winter-run sized juvenile Chinook Salmon exited the Delta between January 31 and May 20, with peak emigration occurring in the month of April (Figure 7). The relative abundance of wild origin winter-run sized Chinook exiting the Delta was similar to the past 11 years, excluding the high abundance we observed in the 2017 field year (Figure 8). No winter-run Chinook Salmon were detected in the Bay region seines.

Spring-, fall-, and late fall-run sized juvenile Chinook Salmon emigrated from the Delta between October 1 and July 24, with peak emigration occurring in the month of May. From October to March, the relative abundance was low and primarily consisted of hatchery origin fish (Figure 7). Wild origin fish were not common in catches until April. The earlier emigration of hatchery origin juveniles was likely due to a combination of factors that affected their residency time within the Delta, including the relative size and maturation state of individuals and the timing and location of their release (Pearcy et al. 1989). The relative abundance of wild origin juveniles exiting the Delta in the 2019 field year was the second highest since we began our estimates in 2008 (Figure 8). We also observed these juvenile Chinook in our Bay Seine from March 19 to May 20, which indicated that fry- and parr-sized juveniles emigrated from the Delta and contributed additional migratory phenotypes to the overall Central Valley Chinook Salmon cohort in the 2019 field year (Figure 7). This was the third year in a row that we have recorded a high relative abundance of these juveniles in the Bay (Figure 8). The high relative abundance and diverse migratory phenotypes we observed in the 2019 field year were positive indicators for recruitment in future years (Miller et al. 2010).

Juvenile Steelhead exited the Delta between January 14 and May 14, with peak emigration occurring in the month of March (Figure 7). Our total catch for the year was dominated by hatchery origin fish (130 of 141 individuals or 92.2%) and the low relative abundance of wild origin fish fell within the general range we have observed for the past 10 years (Figure 8). No Steelhead were detected in the Bay region seines in the 2019 field year.

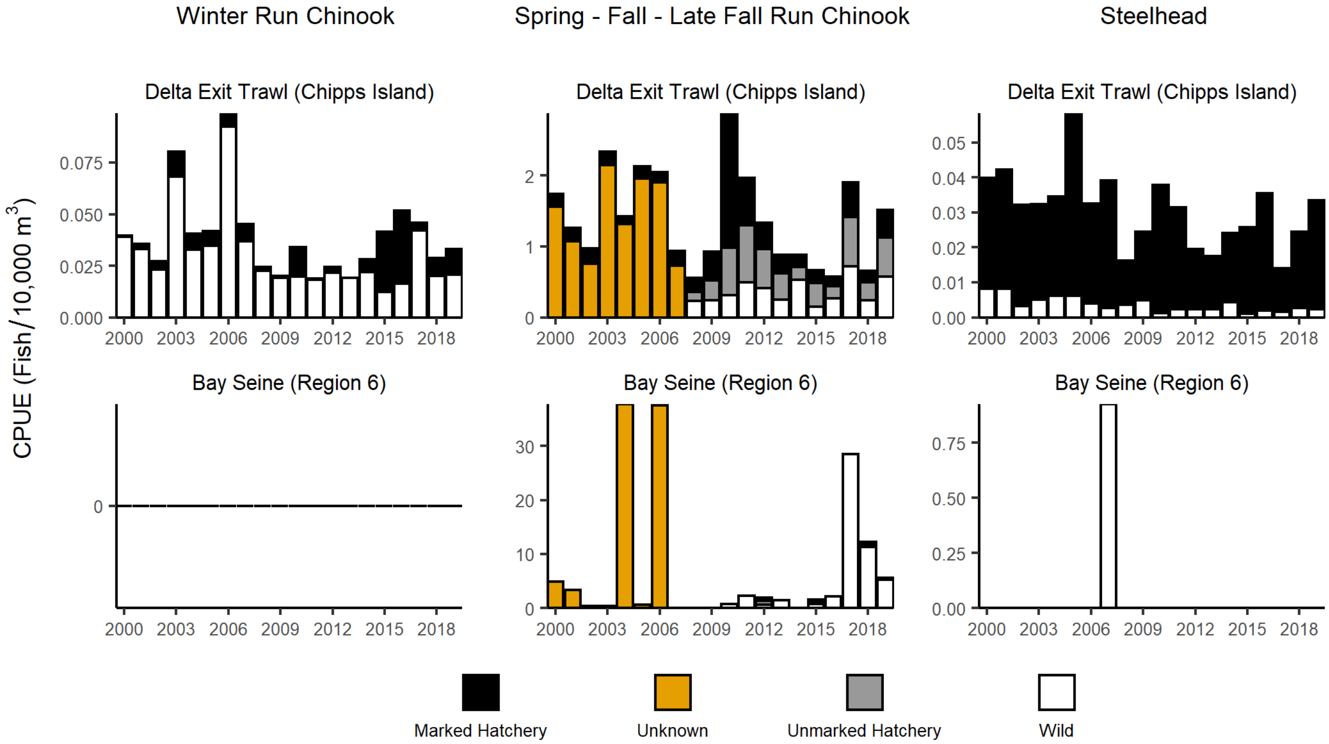

Figure 8. Annual relative abundance trends of juvenile salmonids emigrating the Delta from 2000 to 2019. Note that y-axis scales vary by species and sampling location.

Management Implications

Since 1976, the U.S. Fish and Wildlife Service's Delta Juvenile Fish Monitoring Program (DJFMP) has monitored the annual timing, distribution, and relative abundance of juvenile salmonids throughout the Delta to better our understanding, inform the management, and mitigate the impacts of the CVP and SWP water export operations on salmonid populations. The data collected by the survey allows resource managers and researchers to track changes in the distribution and relative abundance of salmonid populations across time and space, and environmental conditions and management activities. Therefore, the DJFMP salmonid survey remains a critical component of fish management and conservation within the Delta. The full DJFMP dataset, including environmental data not included in this report and a description of sampling procedures are available at DJFMP's Environmental Data Initiative Data Portal (IEP et al. 2020).

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